

MEMORANDUM

To: Ms. Laura Tesch Date: June 28, 2013

Copy To: Mr. Dan Easton File No.: VA101-176/44-A.00

From: Jaime Cathcart; Les Galbraith Cont. No.: VA13-01420

Re: Review of the Bristol Bay Assessment; EPA Docket ID No. EPA-HQ-ORD-2013-0189

The following text highlights the main issues or deficiencies noted by Knight Piésold Ltd. (KPL) when reviewing the US Environmental Protection Agency's (EPA) document "An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska," Second External Review Draft, EPA 910-R-12-004Ba, dated April 2013 ("the Assessment"). Detailed comments addressing specific excerpts from the Assessment are provided in the attached Table 1. The comments supplement a previous review summary by KPL (document VA12-01415) pertaining to the EPA's May 2012 draft Assessment Report for public comment titled "An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska". The comments were prepared by the undersigned Professional Engineers, who have decades of experience with the design and operation of tailings dams, including tailings dams in Alaska. Their curricula vitae are attached.

KPL has made comments pertaining to five main subject areas:

1. Tailings Storage Facility Design
2. Tailings Storage Facility Operations
3. Mine Closure
4. Potential Dam Failure Scenarios and Probabilities, and
5. Hydrology and Flow Reductions.

Tailings Storage Facility Design

The Assessment includes an evaluation of earthquake design criteria from the Initial Application Package for Approval to Construct a Dam, which was submitted by Northern Dynasty Minerals (NDM) to the Alaska Department of Natural Resources in 2006. These design criteria are out of date and are not representative of the current design standards being adopted for the Pebble Project. On-going work has included the development of a detailed deterministic seismic hazard assessment for the project site that is far more extensive than the one referenced in the Assessment. An updated seismic hazard assessment is on-going and includes an evaluation of potential Lake Clark fault extensions and a "floating" maximum background earthquake. Thus, for the Assessment to use a hypothetical mine scenario and design criteria inconsistent with the regulatory requirements in Alaska is a flawed approach; and invalidates any conclusions.

Tailings Storage Facility Operations

The Assessment makes a number of invalid assumptions about tailings storage operations, and in particular about water and waste management practices. To begin with, it makes unwarranted statements that assume that operators will violate their discharge permits, including the statement that "... the record of analogous mines indicates that releases of water contaminated beyond permit limits would be likely over the life of any mine at the Pebble deposit." This statement in the Assessment follows a reference to the report by Earthworks (2012), *U.S. Copper Porphyry Mines Report: The Track Record of Water Quality Impacts Resulting from Pipeline Spills, Tailings Failures and Water Collection and Treatment Failure*, which has been criticized by the Peer reviewers of the EPA Assessment. Furthermore, the Assessment reports that treated water returned to streams would be dictated by mining needs, rather than the needs of aquatic resources. The Assessment also ignores the fact that standard mining mitigation practices and designs include seepage control measures that are monitored and

maintained. It makes inflated estimates of total seepage rates for different assumed mine scenarios, which do not account for seepage control features that would be part of any new TSF dam design in Alaska.

Potential Dam Failure Scenarios and Probabilities

The Assessment offers both earthquakes and overtopping as possible TSF dam failure scenarios, and conveys the false message that failure of a dam is not only possible but probable. The statistics that it uses to support this assertion are based on historical dam failures, which to a large extent are not relevant to modern tailings dams because of improved designs, more stringent regulatory oversight, and higher operating standards. Accordingly, with a non-representative sample, the statistics are meaningless. There is some recognition of this deficiency, and in an effort to address it, the Assessment relies heavily on a paper by Silva et al. (2008) that presents probabilities of failure based on “quantified expert judgment”, rather than a rigorous statistical analysis. These probability values are not statistically defensible, and at best can be considered very rough estimates. Though these values may be appropriate for use in a comparative analysis for assessing relative risk, they are not appropriate for assigning absolute risk, as done by the Assessment. The Assessment further underscores the inadequacy of its analysis by quoting probability values for a dam category that could not be permitted in Alaska (state-of-the-practice engineering would be required), and then assigning probabilities of tailings dam failure from all causes by simply prorating the probability of slope failure by the ratio of total failures to slope failure, which is statistically invalid and nonsensical.

Mine Closure

The Assessment outlines a number of hypothetical problems associated with mine closure, which are all predicated on the assumption that there will be insufficient funding and/or political will to inspect and manage the facilities in a manner that will protect the environment in perpetuity. Adequate bonding to reclaim and stabilize the site – including monitoring, maintenance, and upgrading or replacement of treatment systems as new technologies are developed – would be needed before any development could be permitted to proceed. Bonding requirements would encompass a full suite of potential closure scenarios, including premature closure. The Assessment further maintains that use of modern technology to construct tailings dams increases risk because it is untested over long periods. However, modern dam design technologies are based on proven scientific/engineering principles and there is no basis for asserting that they will not stand the test of time.

Hydrology and Flow Reductions


The Assessment acknowledges that the Pebble Project has invested in a “relatively intensive network of stream gages” in order to characterize streamflows in the area, but this statement requires additional qualification if it is to be properly understood. The network is arguably the most comprehensive and intensive network of streamflow data collection sites ever assembled for a proposed mine, anywhere in the world. The information gained from this network is being used, in part, to calibrate water balance models capable of making detailed predictions of flow reduction impacts in streams in and around the Pebble mine study area, and to guide studies on the location, timing, and rate of treated water discharge to the streams for mitigating potential impacts.

The Assessment quantifies the effects of mining development on downstream aquatic habitat, but doesn’t specify how this is done, and no recognition is given to the inherent variability of such estimates and their dependence on hydrologic processes such as surface water/groundwater interactions. In contrast, regulatory and permitting requirements for mining developments in Alaska necessitate the completion of extensive flow reduction studies with watershed specific models to analytically quantify potential flow reductions and assess different mitigation strategies. Furthermore, the Assessment makes some invalid assumptions about the discharge of treated water to the streams. Firstly, contrary to its stated assumption, the location of treated water discharge during mine operations would not depend on mine water requirements, but rather would be guided by an aquatic habitat impact analysis and mitigation plan. Secondly, contrary to the Assessment’s implied assumption that streamflow reductions would increase during pit filling after the end of mine operations, an even greater amount of water that had been required for tailings management would become available for discharge, so streamflow reductions would actually decrease during pit filling if required to meet streamflow mitigation

objectives. The first priority would be to meet these objectives; water surplus to these objectives would be directed to the pit.


If you have any questions or concerns, please contact the undersigned.

Signed:


per

Jaime Cathcart, Ph.D., P.Eng. – Specialist Engineer - Hydrotechnical

Signed:


Les Galbraith, P.Eng. – Specialist Engineer - Civil

Approved:

Ken Brouwer, P.Eng. – President



Attachments:

Table 1 KP Comments on the 2013 EPA Assessment Report
Consultant Profiles (Curricula Vitae) for Jaime Cathcart, Les Galbraith, and Ken Brouwer

/cjm

Table 1. KP Comments on the 2013 EPA Assessment Report

Page	Section Number	Section title	Excerpt	Contributor	Technical Comment	Citation/Reference	General Subject Area	Comment Category
6-32	6.3	Closure and Post-Closure Site Management	Weathering to the point where these contaminants are present at levels approaching their pre-mining background concentrations would likely take hundreds to thousands of years, resulting in a need for monitoring and management of exposed materials and leachate over that time (Blight 2010). We assume that existing water management structures and the WWTP would be monitored and maintained as part of post-closure operations. Seepage and leachate monitoring and collection systems, as well as the WWTP, might need to be maintained for hundreds to thousands of years. It is impossible to evaluate the success of such long-term collection and treatment systems for mines—no examples exist, because these timeframes exceed both existing systems and most human institutions. Throughout this section, we refer to the potential need for treatment over extended periods. The uncertainty that human institutions have the stability to apply treatment for these timeframes applies to all treatment options.	KP	This implies that mine closure will be inadequate and that the owner will not be responsible for environmental liability. This is not realistic as comprehensive analyses and adequate bonding to reclaim and stabilize the site -- including monitoring, maintenance, and upgrading or replacement of treatment systems as new technologies are developed -- would be needed before any development could be permitted to proceed.		Mine Closure and Water Treatment	Ignores permitting requirements
6-33	6.3.2	Tailings Storage Facilities	Retaining water in the tailings maintains a higher potential for tailings dam failure than if the tailings were drained;	KP	Regardless of whether the tailings are wet or drained, the tailings facility has to be designed to the same safety standard defined by the Alaska Dam Safety Program.		Tailings Storage Facility	Ignores permitting requirements
6-33	6.3.2	Tailings Storage Facilities	Drawing down the water level in the TSF would also provide capacity for unusual precipitation events, reducing the likelihood that a storm would provide enough precipitation to overwhelm capacity and cause tailings dam failure or overtopping.	KP	A permitting requirement for the TSF is the management of the Inflow Design Flood (IDF). The IDF can either be stored in the TSF (a freeboard allowance for the IDF is required at all times) or routed through a spillway. Any mention of dam overtopping is not realistic as a TSF that does not include managing the IDF is out of compliance with the Alaska Dam Safety Program permitting requirements.		Tailings Storage Facility	Ignores permitting requirements
6-36	6.3.5	Premature Closure	If the mine closed because of a drop in commodity price, there would be little incentive to incur the cost of moving or processing millions of metric tons of PAG waste rock. Because premature closure is an unanticipated event, water treatment systems might be insufficient to treat the excessive and persistent volume of low pH water containing high metal concentrations.	KP	A closure bond is required to ensure there are sufficient funds for reclamation and closure, including the possibility of premature closure. The closure bond value is specified by the State to ensure adequacy. Review and update of the closure bond is required every five years. Thus, premature closure is anticipated as a possibility in the planning and bonding process.		Closure	Ignores permitting requirements
7-46	7.3.1.1	Pebble 0.25 Scenario	Overall, it is projected that 73.5% of captured watershed flows would be returned (Table 6-3), but the location of return would vary depending on the mine needs for process water and the location of mine facilities and water treatment.	KP	This is an incorrect statement. In standard practice and design, the discharge locations would be independent of process water needs and the location of the WTP. Discharge locations would be determined by numerous factors including items such as instream flow requirements.		Water Management	Invalid assumption
7-48	7.3.1.4	Post-Closure	After the mine closes, pit dewatering would cease, leading to pit filling. As the pit fills, water from the pit that had been returned to streams via pumping to the WWTP would no longer be available for streamflow.	KP	The effective consumption of water during steady-state operations is the water consumed in the tailings mass. This consumption ceases after shutdown. Additional water is also available for discharge at closure from reclaimed areas. The rate at which the pit is allowed to fill at closure will be a function of how much water is available from the entire mine site and the how much water is required for streamflow. There is no reason to believe that this would be less than during the operational phase.		Water Management	Invalid assumption

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7-51	7.3.2.1	Altered Streamflow Regimes	PLP has invested in a relatively intensive network of stream gages, water temperature monitoring sites, fish assemblage sampling sites, groundwater monitoring wells, and geomorphic cross-section locations.	KP	This is arguably the most comprehensive and intensive network of data collection sites ever assembled for a proposed mine, anywhere in the world.		Baseline data	Invalid statement
8-2	8.1	Water Discharge Sources	Following the termination of mine operations, it is expected that water collection and treatment would continue for waste rock and tailings leachates. If the water is nontoxic, in compliance with all criteria and standards, and its composition is stable or improving, the collection and treatment system may be shut down under permit. Otherwise, treatment would continue in perpetuity—that is, until untreated water quality was acceptable or institutional failures ultimately resulted in abandonment of the system. If the mine operator abandons the site, the State of Alaska should assume operation of the treatment system; if both the mine operator and the State of Alaska abandon the site, untreated leachate would flow to streams draining the site.	KP	<p>This implies that mine closure will be inadequate and that the owner will not be responsible for environmental liability. This is not realistic as comprehensive analyses and adequate bonding to reclaim and stabilize the site -- including monitoring, maintenance, and upgrading or replacement of treatment systems as new technologies are developed -- would be needed before any development could be permitted to proceed.</p> <p>This also implies that the operator and the State abandon the site, which is not realistic.</p>		Closure	Ignores permitting requirements
8-4	8.1.1	Routine Operations	In addition, because the waste rock piles and TSFs would not be lined, some leachates from both would not be captured and would flow to the three receiving streams.	KP	Effective seepage control systems are a mandated, integral part of all mines that would be permitted in Alaska. Liners may be included as part of a seepage management system but there will be some seepage regardless of whether or not a liner is in place as liner systems are not 100% effective in eliminating seepage. Alternatively, seepage management systems may include seepage cutoff walls, seepage collection ponds, and seepage recovery wells that are as effective as liners in managing seepage. Standard mining practice and designs include seepage control systems which are monitored and maintained.		Water Management	Invalid assumption
8-11	8.1.1.1	Tailings Leachate	Total leakage amounts for the three mine scenarios are $1.1 \times 10^6 \text{ m}^3/\text{yr}$ (Pebble 0.25), $2.4 \times 10^6 \text{ m}^3/\text{yr}$ (Pebble 2.0), and $7.2 \times 10^6 \text{ m}^3/\text{yr}$ (Pebble 6.5) (Tables 8-1 through 8-3). These estimates are based on a simple assessment of seepage from the TSFs.	KP	The EPA leakage rate assumption for the tailings leachate assumes that there are no seepage control measures downstream of the main tailings dams. Seepage management systems, which may include seepage collection and recycle ponds, and monitoring wells to collect seepage through the main dams, will be required by State regulators.		Tailings Storage Facility Design	Invalid assumption
8-22	8.1.4	Probability of Contaminant Releases	The USEPA has observed that some operators continue to operate when they know that treatment is ineffective and not meeting standards. Hence, the record of analogous mines indicates that releases of water contaminated beyond permit limits would be likely over the life of any mine at the Pebble deposit.	KP	This section is also speculative. It assumes that Pebble will willingly and knowingly violate its discharge permits, and that State agencies will fail to enforce its permits.		Water Management	Invalid statement

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Page	Section Number	Section title	Excerpt	Contributor	Technical Comment	Citation/Reference	General Subject Area	Comment Category
9-3	Box 9-1	Examples of Historical Tailings Dam Failures	<p>The tailings dam failures below illustrate the characteristics and potential consequences of a tailings dam failure. The details of the design, construction, or operation of any tailings dams constructed for mines in the Bristol Bay watershed would not be the same as these mine tailings dams, but these examples demonstrate that tailings dam failures can occur, and illustrate how these failures may affect downstream areas. In addition, the dams in these failure examples were significantly smaller than the dams in our mine scenarios.</p> <p>Aznalcóllar Tailings Dam, Los Frailes Mine, Seville, Spain, 1998. Stava, Italy, 1985. Aurul S.A. Mine, Baia Mare, Romania, 2000. Tennessee Valley Authority Kingston Fossil Plant, Roane County, Tennessee, USA, 2008.</p>	KP	<p>These tailings dam failures were discussed by KP in 2012 and are not relevant to the Pebble Project. Although the assessment report states that the Pebble TSF design, construction, and operation would be different than the TSF failures mentioned in Box 9-1, the implication is that it is still a tailings dam and that all tailings dams have the same general characteristics.</p> <p>The TSF failures identified in Box 9-1 are not relevant to the TSF concept presented in the assessment report.</p> <p>Last sentence implies that larger dams are more likely to fail but does not provide any justification for this.</p>		Tailings Dam/TSF	Invalid assumption
9-4	9.1.1	Causes of Tailings Dam Failures	Table 9-1. Number and causes of tailings dam failures at active and inactive tailings dams.	KP	<p>The table includes dam failures from upstream construction dams and water dams. Removing the dam failures from the table associated with upstream construction dams, water dams, and unknown dams reduces the number of dam failures from 135 to 9. Furthermore, all 9 failures were the result of conditions that would not be permitted under the Alaska Dam Safety Program. This is relevant as the Assessment uses the total number of dam failures as part of its probability of failure analyses for the Pebble dam, which is neither an upstream construction dam or a water dam.</p> <p>The sample is not representative of the Pebble dam scenario or the regulatory environment in Alaska.</p>		Tailings Dam/TSF	Invalid assumption
9-9	Box 9-2	Selecting Earthquake Characteristics for Design Criteria	<p>The Initial Application Package for Approval to Construct a Dam submitted by Northern Dynasty Minerals (NDM) to the Alaska Department of Natural Resources (NDM 2006) included a seismic safety and design analysis prepared by Knight Piésold Consulting that identified the following design criteria for the tailings dams at the storage facility.</p> <ul style="list-style-type: none">• OBE return period of 200 years, magnitude 7.5.• MDE return period of 2,500 years, magnitude 7.8, with maximum ground acceleration of 0.3g, based on Castle Mountain Fault data.	KP	<p>The values for the OBE and the MDE are the upper limits for a Class II dam in Alaska, as defined by the Alaska Dam Safety Program (ADSP).</p> <p>These design criteria are out of date and are not representative of the current design standards being adopted for the Pebble Project.</p>		Tailings Dam/TSF	New information
9-9	Box 9-2	Selecting Earthquake Characteristics for Design Criteria	Northern Dynasty Minerals used a deterministic evaluation to select the MDE and MCE, which were deemed equivalent for the preliminary safety design. In the application, NDM reports that the preliminary design incorporates additional safety factors, including design of storage facility embankments to withstand the effects of the MDE and a distant magnitude 9.2 event. Ghaffari et al. (2011) state that an MCE of magnitude 7.5 with 0.44g to 0.47g maximum ground acceleration was used in the stability calculations for the tailings dam design. Although the design specifications proposed in Ghaffari et al. (2011) exceed the minimum requirements for dams in Alaska, the deterministic dataset used is small and contains considerable uncertainties, which could lead to an underestimate of the potential seismic risk.	KP	The Assessment references preliminary design criteria that are no longer relevant. The current deterministic dataset associated with determining design earthquakes is far more comprehensive.		Tailings Dam/TSF	New information

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9-10	9.1.2	Probability of Tailings Dam Failures	Combining the required factor of safety with the correlations among level of engineering, factor of safety, and slope failure probability (Figure 9-2) derived from Silva et al. (2008) yields an expected annual probability of slope failure between 0.0001 (Category II) and 0.000001 (Category I). This translates to one tailings dam failure due to slope failure every 10,000 to 1 million dam years.	KP	The slope failure probability values presented by Silva are based on "quantified expert judgment," rather than a rigorous statistical analysis, so the probability values are not statistically defensible. The probability values can be considered very rough estimates, at best, and though appropriate for use in a comparative analysis for assessing relative risk, as intended, they are not appropriate for assigning absolute risk, as done in the Assessment.		Tailings Dam/TSF	Analysis is invalid because the probabilities of failure are not statistically based or rigorously defensible.
9-10	9.1.2	Probability of Tailings Dam Failures	This translates to one tailings dam failure due to slope failure every 10,000 to 1 million dam years. The upper bound of this range is lower than the historical average of 0.00050 (1 failure every 2,000 dam years) for tailings dams. This is partly because slope failure is only one of several possible failure mechanisms, but it also suggests that past tailings dams may have been designed for lower safety factors or designed, constructed, operated, or monitored to lower engineering standards. As shown in Table 9-1, slope failures only account for about 25% of all tailings dam failures with known causes. Thus, the probability of failure from all causes may be about four times higher than dam failures from slope instability alone (an expected annual probability of failure between 0.0004 and 0.000004 or one tailings dam failure every 2,500 to 250,000 dam years), when all potential failure causes are considered, albeit recognizing that the small dataset may not be representative.	KP	The approach used to assign probabilities of tailings dam failure from all causes is simplistic, mathematically incorrect, and statistically invalid. In particular, dividing probabilities based on "quantified expert judgment" by four to account for failures other than slope failures is nonsensical.		Tailings Dam/TSF	Analysis is statistically invalid.
9-13	9.3	Tailings Dam Failure via Flooding and Overtopping	While a variety of failure mechanisms could cause a failure, this assessment used an overtopping scenario.	KP	A dam that has the potential for overtopping is not permissible in Alaska. It should be stated in the document that overtopping is not a realistic scenario, but rather a scenario selected simply for modeling purposes to assess the potential effects of a dam breach. The dam will have to provide storage for, or routing of, the design flood event.		Tailings Storage Facility Design	Invalid assumption
9-13	9.3	Tailings Dam Failure via Flooding and Overtopping	In both cases, we assumed 20% of the impounded tailings would be mobilized (Azam and Li 2010, Dalpatram 2011).	KP	The volume of tailings released would depend on a large number of factors, and the very approximate nature of the estimate is not conveyed in the text.		Tailings Dam/TSF	Uncertainty of the value is not conveyed
9-14	Box 9-3	Modeling the Probable Maximum Flood Hydrograph at TSF 1	The PMF is used to determine appropriate spillway/bypass facilities, or to predict the greatest flood that can cause failure.	KP	The PMF is not the greatest flood that can cause failure, it is simply the largest theoretically conceivable flood event.		Tailings Dam/TSF	Terminology is technically incorrect.
9-14	Box 9-3	Modeling the Probable Maximum Flood Hydrograph at TSF 1	Basin characteristics for the TSF 1 site and the PMP were applied to the SCS Type 1 hydrograph methodology to model data for the probable PMF hydrograph.	KP	There is no such thing as an SCS Type 1 hydrograph methodology. It is more correctly referred to as the SCS Method, the SCS Unit Hydrograph Method, or the TR-20 Rainfall-Runoff Model. Use of this approach requires the selection of a rainfall distribution, and in this case they appear to have selected an SCS Type 1 rainfall distribution (which is debatable in itself, since they used a less severe and more scientifically justified Type IA rainfall distribution in the 2012 assessment report).		Tailings Dam/TSF	Terminology is technically incorrect.

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9-15	Box 9-4	Modeling Hydrologic Characteristics of Tailings Dam Failures	If sufficient freeboard is maintained, it would be possible to capture and retain the expected volume of the PMF in the TSF. However, to examine potential downstream effects in the event of a tailings dam failure, we assume that sufficient freeboard would not exist and overtopping would occur. This may be less likely when the TSF would be actively monitored and maintained, but barring human error in the near term, may be more representative of post-closure conditions in the future.	KP	At post-closure the facility would have a spillway that would safely convey the peak flow of the design flood, so it is not possible that this event would occur as assumed. On-going monitoring and maintenance is inevitable and the Assessment Report assumptions of site abandonment is not realistic because it is illegal (and non-permittable).		Tailings Dam/TSF	Analysis is inaccurate
9-15	Box 9-4	Modeling Hydrologic Characteristics of Tailings Dam Failures	Under both dam failure scenarios, results were modeled for 30 km (18.6 miles) downstream, from the face of the TSF 1 dam down the North Fork Koktuli River valley to the confluence of the South and North Fork Koktuli Rivers. The extension of the simulation beyond this point would have introduced significant error and uncertainty associated with the contribution of the South Fork Koktuli River flows.	KP	The text implies certainty in the presented analysis, where there is very little. This is the only mention of significant error and uncertainty pertaining to the dam breach modeling, and the omission of further discussion implies that the analysis has a reasonably high level of certainty. The uncertainty in the estimation of the peak flows resulting from the tailings dam breach modeling is extremely high. Many key assumptions that the model results are very sensitive to are not discussed, including the size of the dam breach, the rate of breach development, and details of the downstream topography.		Tailings Dam/TSF	Uncertainty of the analysis is not conveyed
9-15	3.8.2	Potential Climate Change Effects	With warmer temperatures and changes in the type, timing, and amount of precipitation, there will likely be changes in snowpack, a shift in the timing of spring snowmelt, and changes in the type of precipitation falling (Barnett et al. 2005). With these changes, there will be alterations to the natural flow regime in both magnitude and timing, and a likely decline in seasonal water availability, mirroring already observed changes in other systems such as the Pacific Northwest (Mote et al. 2003).	KP	The statement of a likely decline in seasonal water availability is not consistent with the results in Table 3-7, which indicate an increase in precipitation for all seasons, and the results in Table 3-8, which indicate an increase in the average annual water surplus.		Climate Change	Contradictory information
9-15	9.3.1	Hydrologic Characteristics	Despite this gage measuring the runoff from a 2,551-km ² watershed, the peak flow was well below the predicted release from a breach in the Pebble 0.25 TSF, which would drain an area of only 14 km ² .	KP	Despite indicating in 2012 comments that the drainage area is 25,550 km ² , the Assessment still reports the drainage area as 2551 km ² .		Tailings Dam/TSF	Erroneous value
11	2.1.2 Appendix I	Closure and Post Closure	Closure requires the TSF to have either a continuous water cover or an engineered cover to prevent oxidation of tailings. Sufficient capital is required to finance inspections, maintenance, and repairs in post-closure for as long as the tailings exist. Closure of a TSF includes containment/encapsulation, minimization of seepage, stabilization with a surface cover to prevent erosion and infiltration, diversions and collection of precipitation, and design of final landform to minimize post-closure maintenance (the final landform desired should be considered during the planning phase). Regardless of the type of reclamation used for closure, the reclaimed facility must be monitored and maintained to ensure stability over time. Post-closure monitoring for contaminant transport is the same as during the operational phase, with piezometers for assessment of ground water mounding and monitoring wells for groundwater quality. The reclaimed facility should be monitored for any deformations, structural changes, or weaknesses, and the surfaces should be inspected for intrusion by animals, humans, or vegetation, any of which could compromise long-term stability.	KP	This is an example of a correct statement in Appendix I that is ignored in other areas of the Assessment Report and in the Executive Summary.		Tailings Storage Facility Design	Inconsistent

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12	Appendix I	Accidents and Failures	As reported in Davies (Davies 2001), upstream constructed dams are more susceptible to liquefaction flow events and are solely responsible for all major static liquefaction events; the author also states that earthquakes are of little concern for non-upstream dams.	KP	An additional example from Appendix I that tends to contradict the Assessment Report assertion in the remainder of the document that “failures are likely to occur” as a result of earthquakes.		Tailings Dam/TSF	Contradictory information
14-16	14.6	Summary of Uncertainties in Mine Design and Operation	The performance of modern technology in the construction of tailings dams is untested and unknown in the face of centuries of extreme events such as earthquakes and major storms.	KP	The same can be said for the construction of any major civil works, including bridges and buildings. Modern dam design technologies are based on proven scientific/engineering principles and there is no basis for asserting that they will not stand the test of time.		Tailings Dam/TSF	Unqualified statement.
14-16	14.6	Summary of Uncertainties in Mine Design and Operation	The promises of today’s mine developers may not be carried through by future generations of operators <u>whose sole obligation</u> is to the shareholders of their time.	KP	Speculative. What is important is the basis for which the facilities are permitted by State agencies, not the promises made by today’s mine developers of future owners.		Risk and Uncertainty	Unqualified statement.
14-17	14.7	Summary of Risks under the Mine Scenarios	Reduced flow from water use would significantly degrade additional stream reaches (Table 14-2) and an unquantifiable area of wetland habitat.	KP	Speculative and unqualified. Pebble is conducting extensive flow reduction and aquatic habitat studies to scientifically assess the possible effects of flow reductions. In some instances, flow reductions, both with and without mitigative flow releases, can enhance habitat usability.		Flow Reductions	Unqualified statement.
14-17	Table 14-2	Summary of Risks under the Mine Scenarios	>20% flow reduction Stream length affected: 15 km, 26 km, 54 km for the three different mine sizes considered.	KP	It is not specified how these channel lengths were computed. It was likely done on the basis of basin area reduction, but detailed watershed modeling studies have shown that potential flow reductions are not directly related to drainage area and also can vary at one location throughout the year.		Flow Reductions	Invalid assumption

JAIME CATHCART, P.ENG., Ph.D.

SPECIALIST ENGINEER

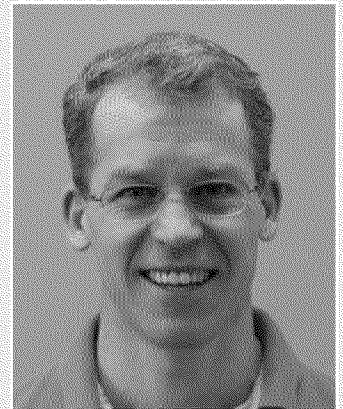
Dr. Jaime Cathcart has been employed at Knight Piésold Ltd., Vancouver since 1993. He is a Civil Engineer with a doctorate in Hydrology from the University of British Columbia, and has practiced for over 20 years as a Consulting Engineer in the mining and hydroelectric industries. He carries the title of Specialist Engineer at Knight Piésold Ltd., and in this capacity, he is responsible for overseeing all hydrologic work in the KP Canada practices. In addition, he is involved with water management and hydraulic design studies for mining, water supply and hydroelectric projects.

AREAS OF EXPERTISE

- Interpretation of Meteorologic and Hydrologic Data – Assessment of data for environmental and engineering studies associated with mine development plans and permit applications, including the application of knowledge regarding factors that influence hydrometeorologic processes and data collection techniques for the purposes of interpreting and understanding data patterns
- Collection of Hydrologic Data – Planning and implementing of hydrologic data collection stations, including site and equipment selection, development of rating curves and data QA/QC
- Water Balance Models – Development of water balance models for both impact assessment and water management design purposes
- Design of Hydraulic Structures – Culverts, ditches, sediment control ponds, spillways, intakes, pipelines, riprap protection, etc.
- Statistical Analyses – Application of statistical methods and tools for probability and risk assessments
- Flood Studies – Hydraulic modelling of river ways using HEC-RAS for defining flood levels and hazard zones, and for exploring flood mitigation alternatives
- Hydrologic Modelling of Watersheds and River Basin Systems – Development and use of hydrologic models for synthesizing long-term daily/hourly flow series and estimating extreme flow values. Examples: UBC Watershed Model, HydroCAD™ and regionally based models.

SPECIFIC RELEVANT EXPERIENCE

- **Brule Coal Mine, BC, Canada** – Hydrometeorological studies and hydraulic design of water management and sediment control structures
- **Schaft Creek Project, BC, Canada** - Specialist level input to hydrometeorological evaluation and water management planning
- **Kensington Project, Alaska, USA** – Hydrometeorological studies and hydraulic design of water management and sediment control structures
- **Pebble Project, Alaska, USA** – Streamflow data collection, hydrometeorological analyses, and senior technical input to environmental permitting and engineering studies
- **Mt. Milligan Project, BC, Canada** – Hydrometeorological studies
- **Ambatovy Project, Madagascar** – Specialist level review of hydrometeorological evaluation and water management planning
- **Campo Morado Project, Mexico** – Hydrometeorological studies and detailed hydraulic design of water management structures
- **Mary River Project, NU, Canada** – Streamflow data collection and hydrometeorological analyses
- **Prosperity Project, BC, Canada** – Hydrometeorological studies, and technical specialist for Federal Panel Review proceedings



**Knight Piésold Ltd.
Canada**

EDUCATION

Ph.D. Resource Management
and Environmental Studies
(Hydrology)

University of British Columbia
Canada, 2001

M.A. Sc. Hydrotechnical
Engineering
University of British Columbia
Canada, 1993

B.A. Sc. Civil Engineering
University of British Columbia
Canada, 1987

SPECIALIZATIONS

- Interpretation of Meteorologic and Hydrologic Data
- Collection of Hydrologic Data
- Water Balance Modelling
- Design of Hydraulic Structures
- Statistical Analyses
- Flood Studies
- Hydrologic Modelling of Watersheds and River Basin Systems

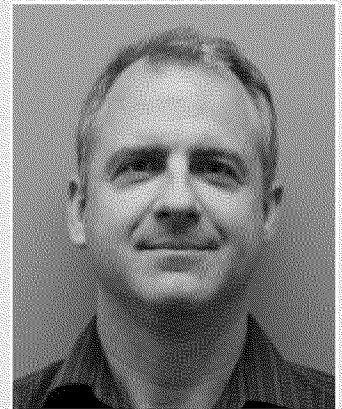
LES GALBRAITH, P.ENG.

SPECIALIST ENGINEER/PROJECT MANAGER

Mr. Les Galbraith has been employed at Knight Piésold since 1996. He is a Civil Engineer with 17 years of experience in providing civil and geotechnical engineering support to mining and hydroelectric projects. His experience includes project management, site investigations, construction supervision of tailings embankments and heap leach pads, seepage and groundwater modelling, stability and seepage modelling, foundation assessments, and hydrology. He has project experience in Canada, USA, Philippines, Cuba, Honduras and Romania. Mr. Galbraith is a licensed Professional Engineer in British Columbia.

SPECIFIC RELEVANT EXPERIENCE

- **Pebble Project, Alaska, USA** – Project management, tailings and waste rock management, dam design, and water management
- **Bokan Project, Alaska** - Project manager and QP for the waste and water management components for the PEA.
- **Cantung Mine, Northwest Territories** – Project management, tailings and water management, dam design
- **Spanish Mountain Gold Project, British Columbia** – Project manager and QP for the waste and water management components for the PEA and the prefeasibility studies.
- **Xietongmen Project, Tibet** - Review of waste and water management concepts
- **Mount Polley Mine, BC, Canada** – Project management, geotechnical investigations, dam design and inspections, leach pad design, and construction management
- **Blackdome Mine, BC, Canada** – Tailings dam inspections
- **Ladner Mine, BC, Canada** - Tailings dam inspections
- **Pend Oreille Mine, Washington, USA** – Geotechnical assessment, detailed design, and construction of a new lined tailings disposal facility
- **Red Chris Project, BC, Canada** – Project management and site investigation organization
- **Kemess Mines, BC, Canada** – Project management, geotechnical site investigations, open pit slopes, construction QA/QC and stability modelling
- **Rosia Montana Project, Romania** – Geotechnical site investigations
- **Moa Nickel Project, Cuba** – Geotechnical site investigations and foundation assessment
- **Golden Bear Project, BC, Canada** – Construction management, and QA/QC testing and inspection
- **Prosperity Project, BC, Canada** – Geotechnical site investigation, water management, and stability and seepage modelling
- **Carmacks Copper Project, YT, Canada** – Geotechnical site investigation, stability and seepage modelling, and water management



Knight Piésold Ltd.
Canada

EDUCATION

B.A.Sc. Civil Engineering
University of British Columbia
Canada, 1995

SPECIALIZATIONS

- Project Management
- Mine Waste and Water Management
- Dam Design
- Embankment Seepage and Stability Modelling

KEN J. BROUWER, P.ENG., P.E.

PRESIDENT

Mr. Ken Brouwer is the President of Knight Piésold Ltd. He has been with Knight Piésold Ltd. since 1985 and has over 30 years of experience in site investigations, design, construction, operation and closure of open pit mines, tailings impoundments, heap leach facilities, and water management systems. His extensive experience includes projects in Canada and throughout the Americas, as well as in Asia, Africa and Europe.

AREAS OF EXPERTISE

- Rock mechanics
- Tailings management
- Waste rock management
- Heap leach facilities
- Foundation design
- Slope stability
- Geotechnical
- Dam design
- Groundwater studies
- Water management
- Permitting support
- Project management

SPECIFIC RELEVANT EXPERIENCE

Mr. Brouwer has served as the Project Director, Senior Reviewer and/or Project Manager for the following projects:

- **Asmara North Projects**, Eritrea
- **Robinson Mine, Quadra FNX**, Nevada, USA
- **Montana Resources**, Montana, USA
- **Constancia Project**, Peru
- **Tepal Project, Geologix**, Mexico
- **Black Butte Project**, Montana, USA
- **Sierra Gorda Project**, Chile
- **Mt. Milligan Project**, BC, Canada
- **Schaft Creek**, BC, Canada
- **Prosperity Project**, BC, Canada
- **Casino Project**, YT, Canada
- **Gold Quarry Mine**, Nevada, USA
- **Xietongmen Project**, Tibet
- **Blackwater Project**, BC, Canada
- **Cantung Mine**, NT, Canada
- **Mactung Project**, YT, Canada
- **Sisson Project**, NB, Canada
- **Spanish Mountain**, BC, Canada
- **Debarwa Project**, Eritrea
- **Florence Copper Project**, Arizona, USA
- **Carlota Mine**, Arizona, USA
- **Minto Mine**, YT, Canada
- **Kremnica Project**, Slovakia
- **Kutcho Project**, BC, Canada
- **Kensington Mine**, Alaska, USA
- **Fort Knox Mine**, Alaska, USA
- **Morrison Project**, BC, Canada
- **Niblack Project**, Alaska, USA
- **Golden Bear Mine**, BC, Canada
- **Ceratepe Project**, Turkey
- **Huckleberry Project**, Canada
- **Pebble Project**, Alaska, USA
- **Kitsault Project**, BC, Canada
- **Goodrich Central South Coal Project**, BC, Canada
- **Diablillos Project**, Argentina
- **Willow Creek Mine**, BC, Canada
- **Sedibelo Project**, South Africa
- **Campo Morado Project**, Mexico
- **La Pitarrilla Project**, Mexico
- **Pebble Project**, Alaska, USA
- **Montana Tunnels Mine**, Montana, USA
- **Stillwater and East Boulder Mines**, Montana, USA
- **Kemess North and Kemess South Mine**, BC, Canada
- **Mount Polley Mine**, BC, Canada
- **Pend Oreille Mine**, Washington, USA
- **Malmberg Project**, Greenland
- **Red Chris Project**, BC, Canada
- **Turnagain Project**, BC, Canada
- **Chu Molybdenum Project**, BC, Canada
- **Palmarejo Project**, Mexico
- **Choco 10 Project**, Venezuela
- **Ajax Project**, BC, Canada
- **Nui Phao Project**, Vietnam
- **Cantung Mine**, NWT, Canada
- **Mary River Project**, Nunavut, Canada
- **Ivanhoe Project**, Nevada, USA



Knight Piésold Ltd.
Canada

EDUCATION

M.Eng. Civil Engineering
University of British Columbia
Canada, 1985

B.A.Sc. Geological Engineering
University of British Columbia
Canada, 1982

REGISTERED PROFESSIONAL ENGINEER

British Columbia, Northwest Territories/Nunavut, Alaska, Montana, Washington

SPECIALIZATIONS

- Geotechnical
- Open Pit Slope Stability
- Rock Mechanics
- Mine Permitting
- Mine Tailings Disposal
- Heap Leach Pads
- Hydrogeology
- Reclamation and Closure
- Project Management